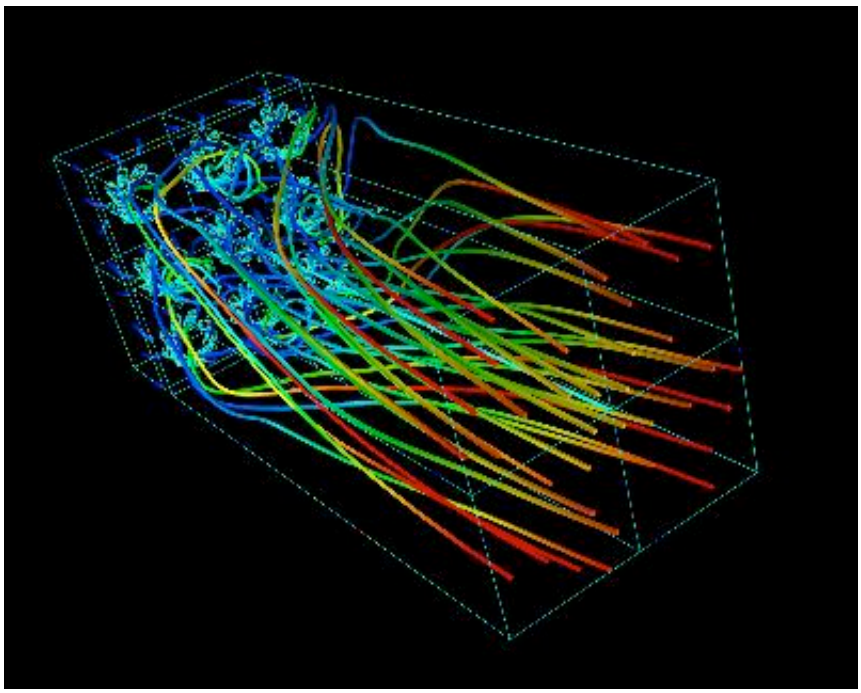
NASA Visualizes New Swirler Aimed at
Improving Jet Engine Performance, Safety

CLEVELAND, Ohio - NASA and the U.S. aviation industry are using new scientific engineering software and high-end visualization to improve jet engine combustion, which has a direct effect on passenger safety, fuel economy and pollution reduction.

"A key goal is to achieve more efficient combustion - both economically and with less pollution," says Dot Carney, a visualization programmer at NASA Glenn Research Center. "We want to make engines that perform better, and safety and maintainability are always concerns."

Visualizing a New Swirler

Scientists at NASA Glenn are currently using the new software, called the National Combustion Code (NCC), to design a next-generation swirler, the device in which fuel and air are mixed within a jet engine. Since the swirler basically controls the combustion process, its design can impact an engine's fuel efficiency, reliability, durability and emissions.



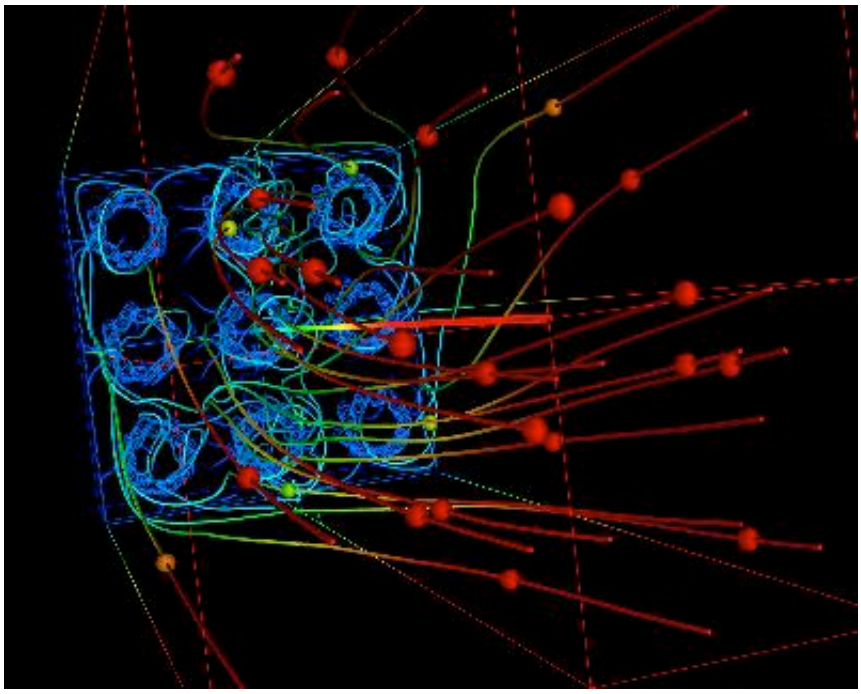
The new code, written by NASA scientists, is teamed with Pro/ENGINEER CAD/CAM software; CFD-GEOM, a mesh generator for creating solid model representations; and EnSight Gold, high-end graphics software for analyzing, visualizing and communicating test results.

One of the direct targets of the research is pollution. Airports are increasingly becoming a large contributor to the nation's air pollution, according to Anthony Iannetti, an aerospace engineer in the combustion branch at NASA Glenn. They are expected to account for as much as 50 percent of pollution in some areas of the country by 2005.

The new swirler design, called a Lean Direct Injection combustion system, lowers NOx (nitrogen oxide), the principal pollutant from jet fuel, by 50 to 70 percent. The system also makes for a safer and more reliable engine, since lower NOx values reduce the chances of an engine flameout.

A Turbulent Tale

Lower NOx values come from reducing the size of the recirculating flow field within the combustion system. The flow fields are analyzed through simulations depicting the turbulence within a 3D prototype of the swirler.



The NCC is better structured to test turbulence than normal CFD code because it includes features designed specifically for the task, including a massively parallel flow solver, advanced chemistry modules, unstructured grids, and turbulence-chemistry models that depict how the air and fuel mixture affects chemical reaction rates.

Turbulence testing starts with a solid geometry model of a prototype swirler created in Pro/ENGINEER. The model is translated into IGES format for use as a NURBS model in CFD-GEOM, the software that generates a computational grid.

The NASA staff uses the computational grid to perform NCC simulations. The resulting models are as large as 10 million computational cells. Four SGI Onyx 2 graphical supercomputers are used in parallel mode with EnSight Gold to extract the results for visualization.

EnSight Gold provides automatic detection and display of major flow features such as shock waves, vortex cores, boundary layer separation and reattachment lines, surface flow topology, and boundary layer characteristics. The software offers several forms of animation - including flipbook, keyframe, particle trace, plane clips or isosurfaces, model (mesh) movement and load - that makes transient data easier to display and understand.

NASA found it particularly valuable to be able to show its visualizations on desktop and room-sized virtual reality displays.

"We use EnSight Gold on the ImmersaDesk and CAVE environments," Iannetti says. "These environments allow us to use the NCC simulation in stereo 3D, where we are able to pick up flow features and phenomena that are not normally seen by other methods such as line plots and cut planes. The 3D environment enables people such as managers, who are not specifically familiar with the geometry, to immediately comprehend what's going on."

Technology for Cleaner Air and More

While the NASA project is still in the concept phase, NCC and EnSight Gold are already delivering results. Simulation and visualization testing takes much less time - five- to 10-times less - than it has in the past, according to Iannetti. And although the swirler is not yet reality, the concept is gaining praise. Iannetti's team received a NASA "Turning Goals into Reality" award for its efforts to reduce jet emissions.

Swirler research is just one of the many uses planned for the NCC in conjunction with EnSight Gold, according to Carney.

"There are decided strategic advantages to having this type of superior technology," Carney says. "Other than helping make the environment cleaner, it can enable the American aerospace industry to be more competitive globally. This is important in terms of jobs, investment dollars and trade balance."

In future studies, Carney says scientists will display EnSight Gold visualizations of NCC results on RAVE, a new immersive display system from Fakespace with three eight-foot by eight-foot screens.

"The RAVE will make complex models more accessible and dramatic than ever," Carney says. "These types of state-of-the-art visualization tools will help bring us closer to our goals for jet engine development. And that will benefit everyone from business to government to the American public."

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